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RESERVOIR CHARACTERIZATION OF AN OFFSHORE NIGER DELTA "X" FIELD USING WELL LOG DATA

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Abstract — **Reservoir characterization of an offshore Niger Delta "X" field was carried out using well log data obtained from two well locations within the field. The objective of the study was to identify probable hydrocarbon reservoirs (pay zones) within the two well locations and to characterize the identified reservoirs for possibly fluid contents. The suite of logs analyzed and interpreted comprised of the gamma ray, resistivity, density and neutron porosity log. After detailed analysis and interpretation of the log signatures, two viable hydrocarbon bearing reservoirs (pay zones) were identified and marked R_1 and R_2. The average reservoir thickness for R_1 was 45ft while that of R_2 was 55ft and both reservoirs have great prospects to produce gas and oil respectively.**

Keywords— **Reservoir Characterization, Well log Data, Offshore Niger Delta, Log Interpretation, Pay Zones**

I. INTRODUCTION

Reservoir characterization is a process of describing various reservoir characteristics using all the available data to provide reliable reservoir models for accurate reservoir performance prediction. The reservoir characteristics include pore and grain size distributions, permeability, porosity, facies distribution and depositional environment. A major requirement needed for describing these characteristics of the reservoir is derivable from well log data. Well log data can provide valuable but indirect information about lithology, texture, sedimentary structures and fluid content of a reservoir. Well logs are continuous information about the measurements of geophysical parameters such as density, resistivity, natural radioactivity, self-potential, neutron porosity and compressional or shear wave velocity of formations traversed through a well bore as a function of depth with intensive vertical resolutions.

The reservoir description and characterization methods utilizing well logs is a significant technical tool with an economic advantage because well logs can provide a continuous record over the entire well when coring cannot be achieved.

Several authors have carried out investigations on reservoir characterization in different sedimentary basins around the world. We present some recent reservoir characterization results; Abu et. al. (2014) conducted a study on quantitative analysis of petrophysical parameters to characterize the reservoir of Narsingdi Gas Field, Bangladesh using well log data. Ohakwere-Eze, M. C. and Adizua, O. F. (2014) qualitatively mapped hydrocarbon bearing reservoirs from preliminary study of well log data over an offshore Niger Delta field. John et. al. (2013) conducted a study to evaluate the petrophysical properties of "SEYI" oil field, Niger delta with a view to understanding the effects of these properties on the reservoirs hydrocarbon prospect and oil productivity of the field. Omoboriowo A.O., et. al. (2012) in their petrophysical analysis of five (5) well logs from the KONGA field in the Niger Delta basin of Nigeria observed that five of the reservoir sand units across the field were hydrocarbon rich. These delineated units had porosity, permeability and acoustic impedance values which were comparable with that obtained for reservoir sands of other Niger Delta fields.

The motivation of the present study is to carry out preliminary reservoir characterization of an offshore Niger Delta field using well log data to identify potential hydrocarbon reservoirs and to ascertain the fluid contents of the identified reservoirs. After identifying the potential hydrocarbon reservoirs, their thicknesses would be estimated. The end result of the reservoir characterization program is very significant for a number of applications such as; subsurface structural mapping, reliable lithology definition, identification of productive prospect zones (potential reservoirs) and an accurate description of the depth and thicknesses of these potential reservoirs. It equally aids in identifying if these potential reservoirs are oil or gas bearing.

1.1. Geologic settings of the Study Area and Overview of the Geology of the Niger Delta

The Niger Delta basin is situated in the gulf of Guinea and extends throughout the Niger Delta province (Klett et. al. 1997). Throughout its history the delta has been fed by Niger, Benue and Cross Rivers, which amongst them drain 10^6 km^2 of the continental lowland savanna. From the apex to the coast, the subsea portion stretches more than 300km covering an area of about 75,000km^2. Below the gulf of Guinea two enormous lobes protrudes a further 250km into the deep waters.

Hydrocarbons have been located in all the depobelts of the Niger Delta, in good quality sandstone reservoirs belonging to the main deltaic sequence. Most of the larger accumulations occur in roll over anticlines in the hanging walls of growth faults where they may be trapped in either dip or fault closures. The hydrocarbons are found in multiple pay sands with relatively short common and adjacent fault blocks usually having the potential to independently accumulate the hydrocarbons. The present field (Figure 1.0) is located in the offshore part of the Niger delta basin.

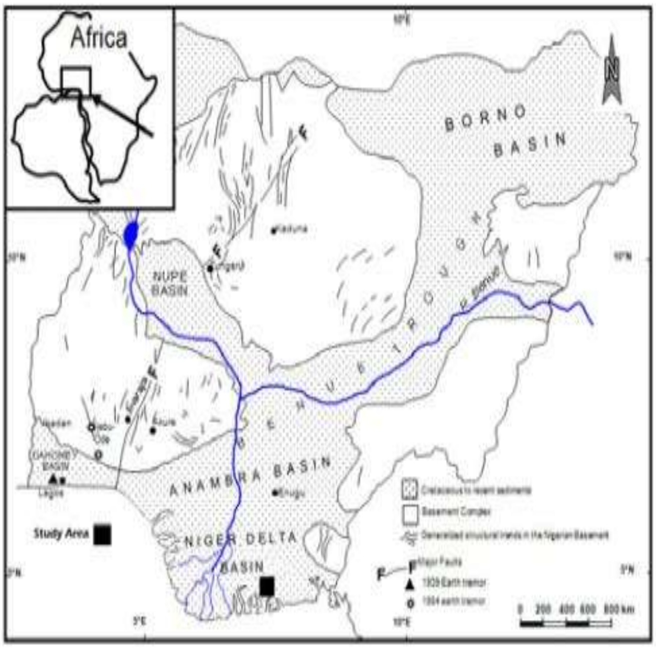

Figure-1.0: Generalized geologic map of Nigeria showing location of the study area. (Adapted after Odeyemi et. al., 1999)

II. Materials and Method

The materials used for the present study comprised of a suite of well logs (gamma ray log, resistivity log, neutron porosity log and density log) obtained from two well locations in the present field in LAS format. The logs were subsequently loaded, digitized and edited using the Hampson- Russel (HR) software tool. The digitized and edited well logs were tagged Aroh 1 and Aroh 2.Aroh 1 (Figure 2.0) shows the suite of well log signatures from well 1, with the gamma ray log in track 1, the resistivity log in track 2, the density log in track 3 and the neutron porosity log in track 4.

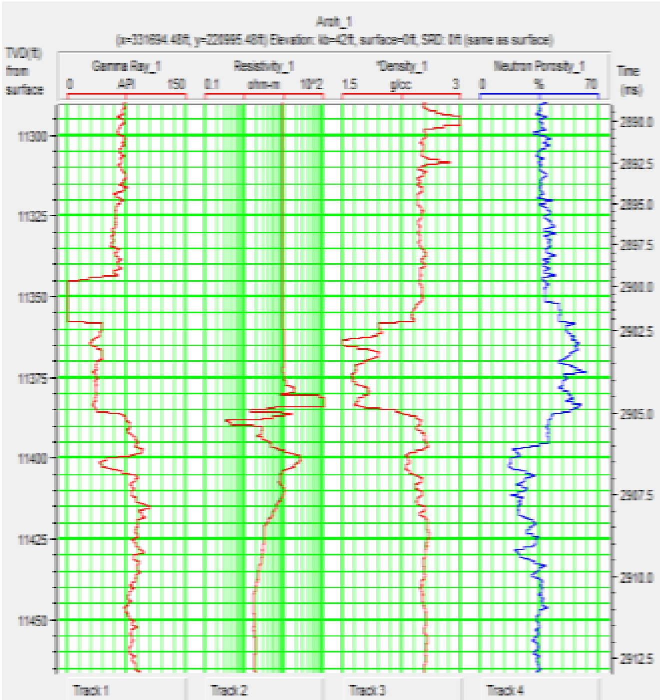

Figure 2.0: The four (4) well log signatures acquired from well 1

Aroh 2 (Figure 3.0) equally shows the display of the suite of well log signatures from well 2, with the gamma ray log in track 1, the resistivity log in track 2, the density log in track 3 and the neutron porosity log in track 4.

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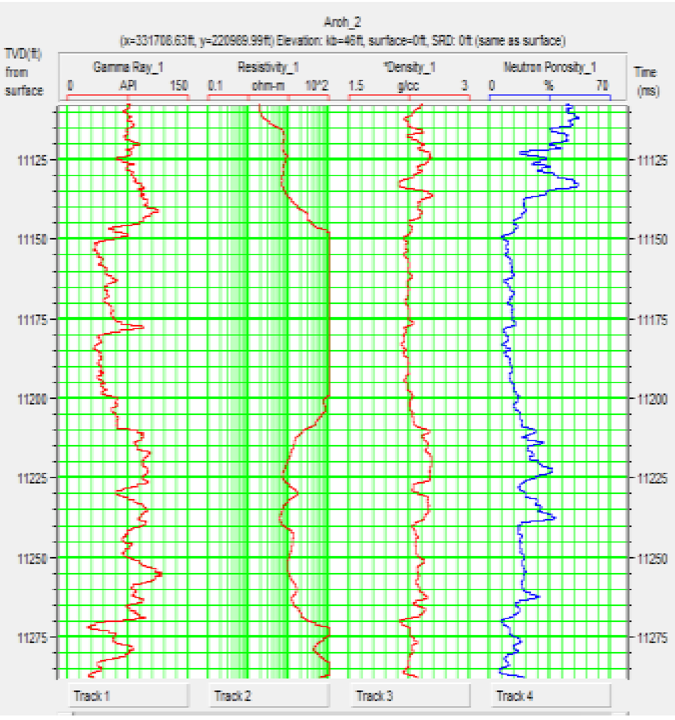

Figure 3.0: The four (4) well log signatures acquired from well 2

2. 1 Well Log Analysis for Reservoir Characterization

The process of interpreting well log data to reliably and effectively characterize a reservoir requires expertise about the analysis and interpretation of the various types of well log. The starting point is to evaluate the log signatures for lithology identification and thereafter delineating or mapping potential reservoir sands. The reservoirs sands are equally analyzed with other log signatures to infer if they are potential hydrocarbon bearing zones. A step further could be taken in the determination of the petrophysical parameters of these probable hydrocarbon zones. The latter step would be the major focus a supplementary paper. The digitized well logs Aroh 1 and Aroh 2 were analyzed and interpreted to infer lithologies and characterize the potential marked reservoir sand units for possible fluid content. The results obtained are hereby presented.

III. RESULTS AND DISCUSSION

From the well log signatures (Aroh 1 and Aroh 2), two viable reservoir sand pay zones (R_1 and R_2) were delineated using the gamma ray responses over the intervals. Intervals with low gamma ray counts were interpreted as potential reservoir sandstone sequences which have relatively low concentration of radioactive materials which accounts for the low gamma counts compared to shale that have higher concentration of radioactive materials which consequently gives rise to a high gamma count.

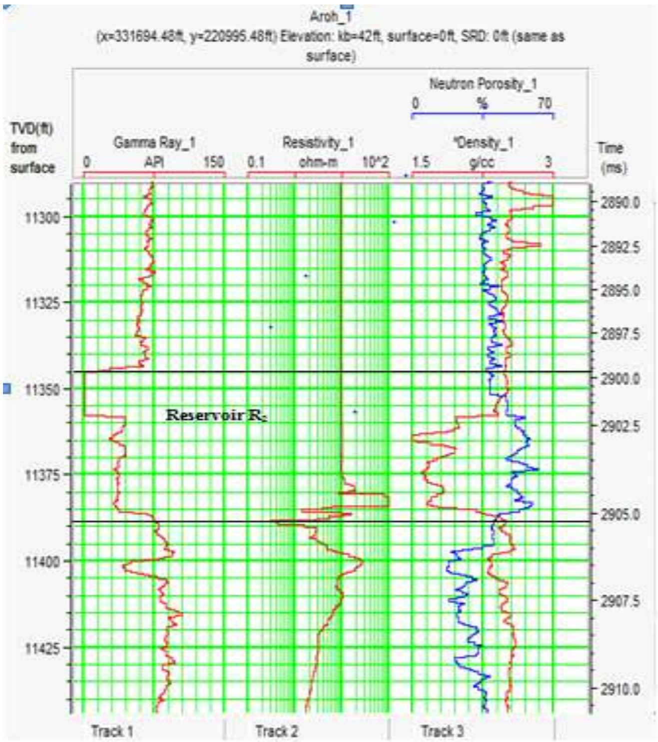

Figure 4.0: The well log signatures for Aroh 1 with density and neutron porosity logs tied together showing delineated reservoir R_2

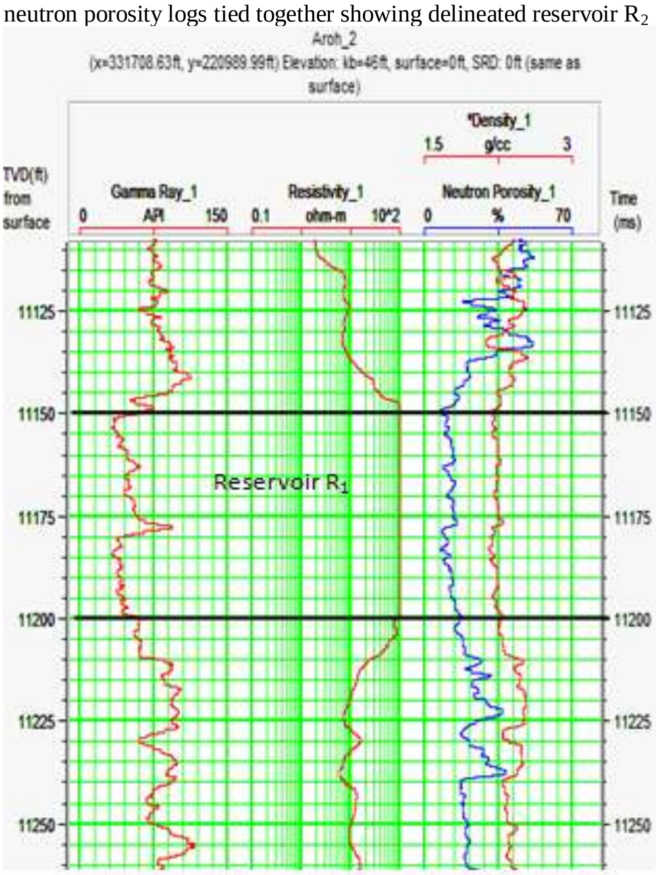

Figure 5.0: The well log signatures for Aroh 2 with density and neutron porosity logs tied together showing delineated reservoir R_1

From Aroh 1, it is observed that from depth ranges of 11345ft to 11390ft (Figure 4.0) that gamma ray response were remarkably low while from Aroh 2, the depth ranges of 11150ft to 11200ft (Figure 5.0) also recorded low gamma ray readings. Low gamma ray readings are positive indications of a potential sandstone lithology which ultimately are good reservoir formations. Spontaneous potential (SP) logs are also good lithology indicators which could have been used to correlate the gamma ray responses but they weren't obtained during the logging program.

After the potential sandstone formations or reservoirs were identified and delineated using the gamma ray log signatures, the next approach adopted for the study was to identify the possible fluid content of the delineated reservoirs. This was achieved by analyzing the trends of the responses from the resistivity, neutron porosity and density logs. For resistivity log, intervals with high resistivity readings were interpreted as hydrocarbon zones. Neutron logs are also used to predict the type of fluid present in the formation since it provides a measure of the hydrogen index. If the hydrogen index measurement is high, it indicates possible presence of hydrocarbons. Density logs equally measures the bulk density of rock formations around the vicinities of the well bore. A rock formation with high porosity has low bulk density which equally is a possible indication of potential hydrocarbon zones. The fluid type (oil or gas) was inferred from the analysis of the joint responses of both the neutron porosity and density logs. Gas formations cause the apparent porosity from density log to increase and porosity from neutron porosity logs to decrease, causing a high density-neutron porosity separation. Oil formations also cause an increase in separation.

IV. CONCLUSIONS

We have attempted the reservoir characterization of an offshore Niger delta "X" field by analyzing and interpreting log responses from well log data acquired in the prospect field. Two viable reservoir pay sands were delineated R_1 and R_2. The average thicknesses of the reservoirs were 50ft and 45ft respectively. Further analysis at these zones, based on the combined responses of both the neutron porosity and density logs, suggests that reservoir R_2 is likely to be oil bearing while R_1 is probably a gas bearing reservoir.

Acknowledgment

We are grateful to the anonymous company who donated well log datasets from the offshore Niger Delta field to our research team for academic purposes. We equally express our profound gratitude to HAMPSELL RUSSELL Company for granting the license to use the Hampsell Rusell ™ well log analysis software for academic research purposes to our team at the University of Port Harcourt, Nigeria.

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